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(54) Method of Breaking a Water-In-Oil Emulsion

(72) Parker, Richard J.;
Ranganathan, Ramaswami;
Lakshmanan, Vaikuntam I.;
Last, Anthony J.,
Canada

(73) Granted to Saskatchewan Oil and Gas Corporation
Canada

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Abstract:

A method is described for breaking a water-in-crude oil emulsion. A crude oil feedstock is tangentially injected into the upper portion of a vortex chamber operating on the vortex principle with the emulsion rotating within the chamber and the velocity of the emulsion increasing toward the center of the vortex whereby concentric layers of emulsion having different tangential velocities apply shear stresses to the dispersed water in the crude oil causing the interfacial film between the water and the oil to rupture. This enables chemical demulsifiers, added prior to the vortex operation, to act more quickly and efficiently. Thereafter, the dewatering of the crude oil is easily accomplished by usual methods.

Method of breaking a water-in-oil emulsion

This invention relates to a method of breaking a water-in-crude oil emulsion.

During the production of crude oil, water is frequently found entrained in the oil as a water-in-oil emulsion. This water is dispersed as fine droplets which do not readily separate from the oil. The crude oil must, therefore, be subjected to one or more of several treating processes to remove the water. These processes may include the addition of chemical demulsifiers, diluents, heat, centrifugation and electrostatic precipitation.

The water droplets in a crude oil emulsion, being heavier than the oil, should sink through the oil to form a separate coherent phase. The rate of separation of the water from the oil is dependent on the size of the droplets, the viscosity of the oil phase, the density difference between the oil and water phases and the strength of any applied force, e.g. gravitational, centrifugal or electrical. The viscosity of the oil and the density difference are both fixed at a constant temperature. The only parameter which can be adjusted to increase the rate of separation is the size of the water droplets. Typical water droplets in a water-in-oil emulsion are in the range of 1-5 μm in diameter. Collisions between individual droplets of water should promote coalescence into larger droplets which subsequently separate more rapidly. This coalescence is often prevented by the presence of a

stabilizing film at the interface between the water droplets and the crude oil. This film may be naturally occuring surface active agents from the oil or fine solids produced from the underground formation along with the oil and water.

It is common practice to add chemical demulsifiers to the emulsion to displace or disrupt the interfacial film. Once the film has been displaced, coalescence of water droplets can more readily take place and larger, faster separating drops are formed. Electrical fields may also be used to disrupt the interfacial film. The water droplets become elliptical in shape when subjected to high electrical charge. In this manner, the interfacial film is stretched and weakened and the energy barrier to coalescence is reduced.

Mechanical rupturing of the film is also known. The use of a hydrocyclone for this purpose is described in Snavely, U.S. Patent 3,489,680. In this system, the emulsion is subjected to shear forces which rupture the film prior to contacting the water droplets with a coalescing membrane.

Another technique of disrupting the interfacial film is the use of a hydroshear as described in Peczeli et al, U.S. Patent 4,142,806. The high shear forces of this technique lead to disruption of the water droplets and so a finer emulsion. This becomes more difficult to separate.

It will, of course, be appreciated that crude oil is a very difficult material to dewater and it is the object of the present invention to provide a low shear technique to disrupt the interfacial film in crude oil emulsions.

Thus, the present invention in its broadest sense relates to a method of breaking a water-in-crude oil emulsion which comprises tangentially injecting a crude oil feedstock containing water together with a demulsifier into at least one tangential inlet of a radially symmetrical (cylindrical) vortex chamber operating on the vortex principle with the emulsion rotating within the chamber along a spiral path toward the central axis and the velocity of the emulsion

increasing toward the center of the vortex whereby concentric layers of emulsion having different tangential velocities apply low shear stresses to the dispersed water in the crude oil, causing the interfacial film between the water and oil to rupture. In this method, the shear stresses are just sufficient to disrupt the interfacial film but not enough to materially affect the water particle sizes in the oil. The product obtained is discharged through at least one discharge nozzle at the central axis of the vortex chamber. Therafter the dewatering of the crude oil is easily carried out by known methods.

The vortex operates at low pressure, e.g. less than 5 p.s.i., and allows the demulsifier to be distributed where the interfacial film is being disrupted and thereby act more quickly and efficiently so that either electrical or centrifugal methods can be used to separate the oil. The demulsifier used can be any of a variety of known chemical demulsifiers.

It is advantageous to add a hydrocarbon solvent to the crude oil feedstock to reduce the viscosity and density of the oil phase prior to the vortex stage. In some instances heat alone can be used to lower the viscosity with the same result.

It may also be desirable to add water either as a solvent for the demulsifier or to provide coalescing sites for the smaller droplets inherently present in the emulsion.

Certain preferred embodiments of the present invention are illustrated by the attached drawings in which:

Figure 1 is an isometric view of a vortex chamber in partial section;

Figure 2 is a plan view in section showing the flow paths;

Figure 3 is an elevational view in section showing the flow pattern; and

Figure 4 is a plan viewing in section of a double discharge vortex chamber.

The vortex chamber is generally shown in Figures 1 to 3 and contains a main body portion 10, an axial discharge nozzle 11 and a tangential inlet tube 13. The oil emulsion enters tangentially through tube 13 under a pressure of less than 5 p.s.i. and rotates within the chamber 10. It is gradually forced toward the center as shown in Figures 2 and 3 and the velocity of the liquid increases as it moves toward the center of the vortex. This forms what are essentially concentric layers of liquid 14 having different tangential velocities and these differing velocities apply shear stresses to the dispersed water in the crude oil emulsion. During this action, the interfacial film between the water and the oil is ruptured and the water droplets can coalesce or fragment depending on the shear stresses and the interfacial tension between the oil and the water.

The product is removed in this condition through discharge nozzle 11 and complete separation of the water from the oil is carried out by usual techniques which are not illustrated.

According to another feature as shown in Figure 4, the chamber 10 may be provided with two discharge nozzles 11 and 11a to increase the capacity.

Certain preferred embodiments of this invention are illustrated by the following examples.

EXAMPLE 1

A water-in-crude oil emulsion was preconditioned by the addition of 35% toluene as a diluent and Natco® L-620 as a chemical demulsifier.

This feedstock was then split into three samples, the first sample being retained for ordinary dewatering, the second sample being passed through a vortex of the type described above and the third sample being subjected to mechanical mixing prior to dewatering. During the vortex stage, some four percent of water was added.

The ease of separation of water from the three emulsions was evaluated using a bench scale electrostatic precipitator. The time necessary for the current passing through the oil to drop to zero was measured, i.e. the peak breakdown time. It had previously been established that if this time was less than two minutes on the bench scale tests, the process would be applicable to full scale field operations. This would provide separated crude oil having pipeline quality (less than 0.5% BSW).

The test conditions and results are set out in Table I below:

Table 1

Sample Volume	200 ml	
Demulsifier	Natco® L-620	
Diluent	Toluene 35%	
Temperature	40°C	
Vortex time	4 minutes	
Added water	4%	
Peak Breakdown Time	No mixing	1.50 minutes
	vortex	0.63 minutes
	electric mixer	0.88 minutes

From the above table, it will be seen that the vortex provided the lowest measured time.

EXAMPLE 2

Example 1 above was repeated precisely except that only 20% toluene was utilized as diluent. The processing conditions and results are set out in Table 2 below:

Table 2

Sample Volume	200 ml	
Demulsifier	Natco® L-620	
Diluent	Toluene 20%	
Temperature	40°C	
Vortex time	4 minutes	
Added water	4%	
Peak Breakdown Time	No mixing	5.13 minutes
	Vortex	1.69 minutes
	Electric mixer	No result

It will be seen from the above table that the vortex provided by far the shortest peak breakdown time and this also showed that when the toluene diluent is dropped to 20%, water could not be removed within two minutes unless the crude oil emulsion had been subjected to the vortex treatment.

EXAMPLE 3

Using the same feedstock as in Examples 1 and 2 above, a further dewatering was carried out, utilizing as demulsifier 1600 ppm of Witco® DRC-164. Three different tests were carried out using different amounts of toluene as diluent, namely 5%, 10% and 20%. The process conditions and the results obtained are shown in Table 3 below:

Table 3

Sample Volume	200 ml	
Demulsifier	Witco® DRC-164	
Concentration	1600 ppm	
Temperature	70°C	
Vortex time	4 minutes	
% Diluent (Toluene)	Peak Breakdown Time (minutes)	Residual Water (%)
20	0.25	0.05
10	1.63	0.31
5	2.88	1.50

It will be seen that the addition of toluene reduced the peak breakdown time and cut down the residual water left in the oil phase. Both the 20% and 10% toluene concentrations gave pipeline quality of oil (<0.5% water) within the two minute time limit.

EXAMPLE 4

The procedure of Example 3 was repeated using 10% toluene as diluent and varying amounts of Witco® DRC-164 demulsifier. The amount of demulsifier ranged from 300 to 1,000 ppm. The process conditions and results obtained are set out in Table 4 below:

Table 4

Sample Volume	200 ml
Demulsifier	Witco® DRC-164
Temperature	70°C
Vortex time	4 minutes
Diluent	Toluene 10%

Demulsifier Concentration (ppm)	Peak Breakdown Time (minutes)	Residual Water (%)
1000	2.44	0.36
900	1.69	0.32
700	1.43	0.15
500	1.63	0.15
400	3.0	0.55
300	2.75	0.55

From the above results it will be seen that the concentration of the demulsifier altered both the peak breakdown time and the residual water. Under the conditions of this example, the optimum demulsifier concentration was 700 ppm which gave the minimum time of 1.43 minutes and least residual water.

Claims:

1. A method for breaking a water-in-crude oil emulsion which comprises adding a demulsifier thereto and injecting the emulsion with demulsifier into at least one tangential inlet of a radially symmetrical vortex chamber operating on the vortex principle with the emulsion rotating within the chamber along a spiral path toward the central axis and the velocity of the emulsion increasing toward the center of the vortex whereby concentric layers of emulsion having different tangential velocities apply shear stresses to the dispersed water in the crude oil sufficient to disrupt the interfacial film between the water and the oil but not enough to materially affect the water particle size in the oil and discharging the product obtained through at least one discharge nozzle at the central axis of the vortex chamber.

2. The method according to claim 1 wherein the emulsion enters the vortex chamber at a pressure of less than 5 p.s.i.

3. The method according to claim 1 wherein a hydrocarbon solvent is added to the crude oil feedstock to reduce the viscosity and density of the oil phase.

4. The method according to claim 1 wherein water is added either as a solvent for the demulsifier or to provide coalescing sites for the smaller droplets inherently present in the emulsion or to remove dissolved or suspended inorganic salts from the emulsion.

5. The method according to claim 1, 2 or 3, wherein the product from the vortex chamber is dewatered in the presence of an electrostatic precipitator.

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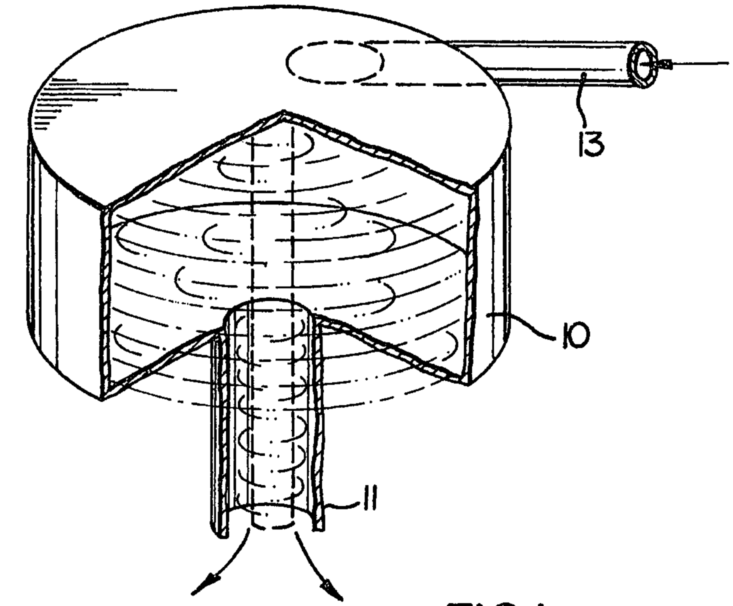

FIG.1

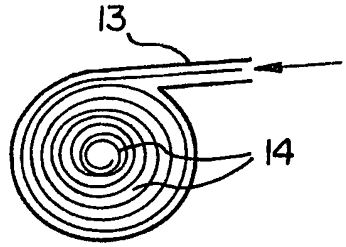

FIG.2

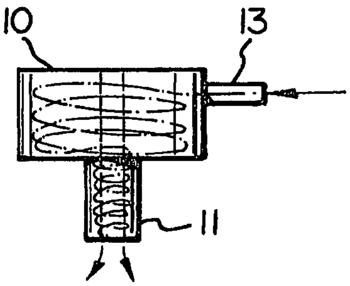

FIG. 3

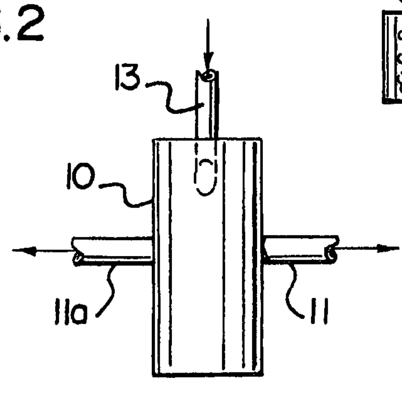

FIG.4

Kirby, Shapira,
Eades, Cohen